In the Drawings:

Please enter the enclosed New Sheet of drawing with one new figure, as required by the Examiner, to show the claimed inventive subject matter. The Figure merely schematically shows an example embodiment of the claimed method steps and further inventive features in a block flow diagram, without introducing any new matter. See claims 1, 2 and 10 to 16, and the written description at page 4 lines 1 to 26, for example.

[RESPONSE CONTINUES ON NEXT PAGE]

REMARKS:

1) The Examiner's attention is directed to applicants' second Information Disclosure Statement being filed together with the present Response. Please consider the IDS and the cited reference, and return an initialed, signed and dated acknowledgment copy of the IDS Form PTO-1449 of February 3, 2009.

2) Referring to the claim listing in item 4) and 6) of the Office Action Summary, note that claim 10 is also pending. The Office Action does not include a particular rejection of claim 10, but also does not indicate that claim 10 recites allowable subject matter. Thus, it appears that claim 10 may simply have been overlooked. Consideration of claim 10 is requested.

3) Referring to section 1 on page 2 of the Office Action, the Examiner's attention is directed to the enclosed drawing transmittal accompanied by a single new sheet of drawing to be added to the application. The new single drawing figure merely schematically shows an example embodiment of the claimed method steps and inventive features in a block flow diagram, to illustrate the inventive subject matter of the present method claims. See claims 1, 2 and 10 to 16, as well as the written description at page 1 lines 4 to 19, page 2 line 23 to page 3 line 20, and page 3 line 26 to page 4 line 26. Thus, this added drawing figure does not introduce any new matter. Entry thereof is respectfully requested. Please withdraw the objection and

indicate approval of the drawing in the next official communication.

4) Referring to section 2 on page 2 of the Office Action, the original specification of this application was a direct literal translation of the foreign language text of a corresponding PCT International Application, in accordance with the PCT procedures. The specification has now been amended in an editorial and formal manner, to better comply with typical US application format and style. Section headings have been added, direct references to claim numbers have been avoided, a few translated text passages have been editorially clarified to facilitate comprehension, and reference has been made to the added new drawing figure. These merely editorial and formal amendments do not introduce any new matter. Entry thereof and withdrawal of the objection to the specification are respectfully requested.

5) Further according to the PCT procedures, the original claims of this application were a direct literal translation of the foreign language PCT claims of the corresponding PCT International Application. The translated claims have now been amended editorially and formally to better comport with typical US claim style, format and practice. These amendments have been made simply for editorial simplification, clarification and streamlining in comparison to the original directly translated text, and have not been submitted for reasons of patentability or for narrowing the scope of the claims. Also, referring to sections 4 to 7 on pages 3 and 4 of the Office Action, the

specific indefinite aspects asserted by the Examiner in claims 11, 13, 15 and 16 have been avoided. In claim 11, the previous optional feature has now been positively recited as a required feature. In claim 13, the previously recited "external connection" has been clarified as --an external light path for illuminating the scene by the modulated light source--. Claims 15 and 16 have been canceled. Thus, all present claims, including claims 11 and 13, definitely and particularly point out and distinctly claim the subject matter of the invention. Please withdraw the rejection under 35 USC 112(2).

6) Referring to the middle of page 4 of the Office Action, the rejection of claims 15 and 16 under 35 USC 101 has been obviated by the cancellation of these claims.

7) New claims 17 to 19 have been added. Claims 17 and 18 depend from claim 1, and claim 19 is a new independent claim. These new claims are supported by and based on subject matter originally disclosed in the other claims and written description as shown in the following table, and do not introduce any new matter. Entry and consideration of the new claims are respectfully requested.

new claims	17	18	19
original support	P 3 L 11-16	P 1 L 4-16 P 3 L 3-20	Cl 1, 2, 14; P 1 L 4 -19; P 2 L 23 - P 3 L 16; P 3 L 26 - P 4 L 26

8) Referring to section 9 on pages 4 to 6 of the Office Action, the rejection of claims 1, 2 and 12 to 16 as obvious over German Patent Laying-Open Publication DE 44 39 298 (Schwarte '298) in view of US Patent 4,950,880 (Hayner) is respectfully traversed.

The Examiner has applied Schwarte '298 as disclosing the basic features of lines 3 to 11 of prior original claim 1. It is acknowledged that Schwarte '298 and the present invention both relate to the same basic underlying distance measurement method, in which a distance is determined from the signal transit time of an emitted light signal that illuminates and is reflected back from a 3D scene and the reflected light is received by an array of pixels. The signal transit time of the emitted signal and the received signal is determined from the phase relation between the phase of the intensity modulation of the modulated emitted signal and the phase of the intensity modulation of the received reflected signal. Namely, this modulation phase relation of the emitted and received signals is used as a measure or indication of the distance traveled by the emitted light and the received reflected light.

It is important to recognize that the pertinent "phase" being evaluated is not the phase of the wavelength of the sinusoidal electromagnetic wave of the light itself, but rather is the phase of an intensity modulation that is imposed (i.e. modulated) onto the emitted light to form the modulated emitted light signal. This intensity modulation of the emitted light signal typically lies in a frequency range of megahertz or gigahertz (e.g. from 10^9 to about 10^{13} Hz). This is in stark contrast, e.g. several orders of magnitude below, the typical

laser frequencies used for the illuminating light, which lie in the range between 10^{14} and 10^{15} Hz, for example. Thus the corresponding wavelengths are also significantly different. Furthermore, the intensity modulation of the emitted light signal can have any desired waveform, and is not limited to a sinusoidal waveform as the underlying electromagnetic wave of the light. Also, the wavelength or frequency of the intensity modulation superimposed on the electromagnetic wave of the light carrier can be varied or adjusted as desired to properly match the expected range of the distance measurement, while the wavelength of the electromagnetic wave is fixed by the color or frequency of the light source. Still further, because the modulation waveform of the intensity modulation superimposed on the light does not have any zero transitions, i.e. does not have alternating positive and negative values but rather only positive intensity values, a superposition of two intensity modulated light signals with a 180° phase shift relative to one another will not lead to a complete canceling-out of the intensity. Similarly, a superposition of two intensity modulated light signals of the same phase will not lead to a doubling of the intensity. This is in clear contrast to the "phase" of the electromagnetic wave of the underlying light, for which the superposition of two 180° out-of-phase electromagnetic waves will completely cancel each other out, while the superposition of two in-phase electromagnetic waves will cause a doubling of the sinusoidal wave amplitude.

In view of the above differences, it is important to recognize the distinction between the "phase" of the modulation of an intensity modulated light signal on the one hand, and the "phase" of the electromagnetic wave of the underlying light on the other hand. It is thus also important not to confuse these two concepts with each other, and it must be recognized that teachings regarding one of these concepts cannot be applied directly to the other of these concepts.

As discussed above, both the present invention and the Schwarte '298 reference use the relationship between the phase position of the modulation of the received reflected signal relative to the phase position of the modulated emitted signal to determine the signal transit time and thus the signal travel distance, respectively individually for each pixel. However, as acknowledged by the Examiner, Schwarte '298 does not disclose steps of calibrating the receiving array as presently claimed. In this regard, the Examiner has cited and applied the Hayner reference.

However, the Hayner reference does not relate to a method of calibrating a 3D image sensor that uses the transit time of a modulated emitted signal and the arising reflected radiation as a measure of distance. Furthermore, the system and method according to Hayner do not use the phase position of a **modulation** of a received reflected radiation signal relative to the phase position of a **modulation** of the modulated emitted signal to determine a distance measurement. Thus, the teachings of Hayner regarding a calibration have nothing to do with calibrating a

multi-pixel array for properly determining a distance measurement according to the present invention or according to the Schwarte '298 reference.

Instead, as expressly pointed out by the Examiner, the calibration disclosed by Hayner is in order to ensure that the receivers of the array are in coherent alignment with one another. Particularly, this means that all of the receivers must be positioned and/or operated so that all of the receivers receive the returned light with phase-uniformity within approximately 1/10 of one wavelength of the light (col. 2 line 61 to col. 3 line 12, col. 4 lines 38 to 68, col. 12 lines 6 to 34). However, due to the repetitive cyclical nature of the sinusoidal electromagnetic wave of the light, the various **individual receivers of the array may be shifted from one another by an integral number of wavelengths** in the direction of the light travel, without affecting the required coherence (see col. 4 lines 46 to 60, col. 7 lines 42 to 49, col. 8 lines 21 to 23). This makes absolutely clear that **the system and method according to Hayner are not used for distance measurement based on a transit time** based on a phase relation of a modulated emitted signal and the arising detected radiation that is reflected from the viewed scene as presently claimed. To the contrary, Hayner makes clear that the absolute phase position of each individual receiver is irrelevant; only the relative phase position of the receiver within a given wavelength of the light wave is relevant, but the number of integral wavelengths between the viewed scene and the receiver has no bearing on the

measurement. Thus, this integral number of wavelengths between the receiver and the viewed scene also can have no bearing on the calibration.

On the other hand, in the present inventive method, it is absolutely crucial not to ignore the distance between the viewed scene and the receiver as measured by a fractional portion of one wavelength or an integer wavelength number plus a fractional portion of a wavelength, because that is used as the basis for determining the transit time of the modulated light signal and thus a distance between the viewed scene and the receiver pixel. In fact, in order to avoid ambiguity in the measurement, the wavelength of the modulation of the intensity of the emitted light signal must be properly matched to the expected range of distance measurement, or the distance measurement must be repeated with at least two different wavelengths of the modulated light signal in order to provide an unambiguous distance measurement based on an unambiguous fractional, or integer plus fractional, wavelength measurement.

The teachings of Hayner to simply ignore the number of integral wavelengths between the viewed scene and the receiver are thus directly contrary to, and would have directed a person of ordinary skill in the art away from, trying to use the calibration method of Hayner in connection with a 3D distance measuring system and method according to Schwarte '298.

Contrary to providing a calibration that would be suitable for calibrating plural pixels of a receiving array of a 3D image sensor for carrying out a distance measurement based on the transit time of a modulated emitted light signal, the system and

method according to Hayner are actually directed toward achieving an increased angular resolution by synthesizing a large collecting aperture by optically and electronically phasing several distributed receivers to ensure that the several receivers are coherent with one another with respect to the received phase position of the received light within any arbitrary single wavelength cycle of the electromagnetic wave of the received light (see abstract, col. 2 lines 20 to col. 3 line 11, col. 3 lines 20 to 68). Rather than determining the distance or range of a target in the viewed scene by measuring the transit time based on the phase relationship of the received reflected signal relative to the modulated emitted signal, the method of Hayner provides the known range and angular position of a target as an input to the CPU, which uses that information to orient and focus the receiving lobe of the array on the target in the viewed scene (col. 12 lines 49 to 54). The whole point of Hayner is not to determine the distance, but rather simply to increase the effective aperture and the effective field of view of the receiver array to an arbitrary large size by spatially distributing the receivers of the array, while keeping them coherent with one another with respect to a phase position within any arbitrary integral wavelength cycle (see col. 13 lines 8 to 10).

On the other hand, the coherence to be achieved by Hayner is irrelevant to the method according to Schwarte '298 and the present invention, which actually carry out the incoherent optical transit-time method for determining the distance (see the present specification at page 1 line 4). As discussed above, the

term "phase" used by Hayner relates to the phase of the electromagnetic wave of the received light, and Hayner aims to achieve a coherence of that phase position of the electromagnetic wave of the received light within any integer wavelength cycle as received by each individual receiver. On the other hand, the "phase" pertinent to the present invention and Schwarte '298 is the phase of the modulation of the intensity that is superimposed on the electromagnetic wave of the light. See the above discussion of the important distinctions between these two concepts.

Contrary to Hayner, the method of the present invention does not involve making the phase coherent in the manner of Hayner. A typical 3D sensor for carrying out the present inventive method has all of the pixels physically arranged on the same semiconductor chip. For that reason, and because the modulation wavelengths are very large relative to the wavelength of the electromagnetic wave of the light carrier, a "coherence" in the sense of Hayner is always present and is not in need of any correction or calibration. Namely, the spatial position of the pixels of the array is uniform along a plane of the semiconductor chip for all of the pixels, and the accuracy of this planar alignment is very high relative to the long wavelength of the intensity modulation compared to the wavelength of the electromagnetic wave of the light. Thus, the several pixels are always coherent in the sense of Hayner. Nonetheless, this is not absolutely necessary according to the invention, and also would not need any correction or calibration, because the wavelength of the electromagnetic wave (i.e. the light) is not relevant, but

rather only the wavelength of the intensity modulation is relevant for determining the distance according to the inventive method. This wavelength of the intensity modulation may be on the order of magnitude of millimeters or centimeters or meters, for example, while the individual pixels of the 3D sensor are typically integrated on a semiconductor chip with a position accuracy on the order of microns. For these reasons, the coherency teachings of Hayner have no relationship to, or suggestion toward, the calibration required by the present inventive method.

For the above reasons, it would not have been possible, and it would not have been sensibly suggested to a person of ordinary skill in the art, to combine the calibration method according to Hayner in the 3D distance measurement method according to Schwarte '298. Still further, even if a coherence calibration according to Hayner would have been used in combination with a distance measurement method according to Schwarte '298, the present invention would not have been suggested, because the calibration method according to Hayner would not have achieved or suggested a calibration according to the present invention as set forth in currently amended claim 1. For example, currently amended claim 1 makes clear that the relevant phase position is a <u>phase position of a **modulation** of the light signal</u>, and that the received signal is used as a measure of distance <u>based on a transit time of the modulated emitted signal and the arising detected radiation that is reflected from the viewed scene</u> and received by the receiving array. These features, e.g. the relevant "phase position", pertain during both the calibration

and the distance measurement. While Schwarte '298 relates to such a distance measurement, Schwarte '298 does not disclose the presently claimed calibration. On the other hand, Hayner discloses a calibration, but that calibration has nothing to do with the presently claimed manner of calibration and distance measurement based on the phase of a modulation of a light signal to determine a transit time of the light signal.

For the above reasons, the invention of currently amended independent claim 1 would not have been obvious over Schwarte '298 in view of Hayner. The dependent claims are patentably distinguishable over the prior art already due to their dependence. The Examiner is respectfully requested to withdraw the rejection of claims 1, 2 and 12 to 16 as obvious over Schwarte '298 in view of Hayner.

9) Referring to section 10 on pages 6 and 7 of the Office Action, the rejection of claims 11 and 12 over Schwarte '298 in view of Hayner and further in view of the article by Lange et al. is respectfully traversed. Claims 11 and 12 depend from claim 1, which has been discussed above in comparison to Schwarte '298 in view of Hayner. The article by Lange et al. discloses distance measurements based on signal transit times or "time-of-flight ranging" using a modulated light source. However, the Lange et al. article does not appear to disclose a calibration process as recited in present independent claim 1 and discussed above. Thus, even a combined consideration of Lange et al. with the two references discussed above would not have suggested the invention of present independent claim 1, and much less dependent claims

11 and 12. For these reasons, please withdraw the rejection of claims 11 and 12 as obvious over Schwarte '298 in view of Hayner and further in view of Lange et al.

10) New dependent claims 17 and 18 recite additional features that further distinguish the invention over the prior art. The Examiner is requested to consider the features of claims 17 and 18 in comparison to the references.

11) New independent claim 19 was drafted "from the ground up" as a fresh approach at covering inventive subject matter with a different claim terminology, style and format in comparison to claim 1, which was based on a direct literal translation of the corresponding foreign language PCT claim of the counterpart PCT International Application. Claim 19 is directed to a method of operating a 3D image sensor including certain steps in a calibration mode and certain steps in an operation mode. For example, the calibration mode involves illuminating the pixels of a receiving array with a modulated calibrating radiation, and demodulating respective output signals of the pixels with a demodulation signal to produce demodulated output signals. The demodulation signal and the modulated calibrating radiation both have a modulation with the same modulation frequency. The calibration further involves determining respective pixel-individual deviations of the demodulated calibration output signals relative to one another or relative to a nominal standard value. Then, in an operation mode, the method involves illuminating a 3D scene with a modulated illuminating radiation

and reflecting this radiation from the 3D scene as reflected radiation that is received with the pixels of the receiving array to produce output signals. These output signals are demodulated with a demodulation signal having the same modulation frequency as the modulated illuminating radiation. Thereby, the demodulation produces demodulated output signals of the pixels. The method further involves compensating these output signals or demodulated output signals based on the abovementioned pixel-individual deviations that were determined during the calibration. Thereby various deviations of the individual pixels (e.g. due to manufacturing tolerances, age-related degradation, temperature-dependence, etc.) can be compensated-out. Finally the method involves determining a respective distance to a respective image point of the 3D scene respectively for each one of the pixels from the demodulated operation output signals of the pixels. In view of the above discussion of the prior art references, for the same reasons, the prior art does not disclose and would not have suggested such steps of a method as defined in present claim 19. Favorable consideration thereof is respectfully requested.

[RESPONSE CONTINUES ON NEXT PAGE]

12) Favorable reconsideration and allowance of the application, including all present claims 1, 2, 10 to 14 and 17 to 19, are respectfully requested.

Respectfully submitted,

By [signature]
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2/3/09

Name: Walter F. Fasse - Date: February 3, 2009